Growth Dynamics in a General Equilibrium Macroeconomic Model for India

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Abstract

Medium-run growth dynamics of a "modern" sector are examined in a simple aggregative general equilibrium macromodel. The effect of agriculture-industry interactions on the growth path are then analysed in a ten-sector disaggregated applied general equilibrium model (AGEM) for agriculture policy analysis. The model endogenously generates a relatively rigid mark-up and large quantity response to shocks. The latter explains endogenous growth amplifications. The model is used to understand the Indian growth experience. The emphasis on dynamics helps to identify policy interventions that, by changing parameters in desirable directions, can amplify growth.

JEL Classification: D58, E32

Key words: applied general equilibrium, agriculture-industry interactions, growth amplifications

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1. Introduction

The objectives in this paper are twofold. First, to explain endogenous medium-run growth in a nonmarket clearing selling; second, examine the effect of intersectoral interactions on the growth path. All this is attempted in an applied general equilibrium model (AGEM) for the Indian economy.

The Walrasian structure of AGEMs ensures that functional relationships are built up from atomistic maximization given preferences and technology and interlinkages between markets are accounted for. However, AGEM modelers have to explain the real world. The difficulties they face in doing this consistently with the theoretical base are mainly to explain nonmarket clearing and to model medium-run dynamic adjustment.

The first is normally solved by postulating mark-up pricing with *ad hoc* mark-ups and the second by between period updates of dynamic variables that are also *ad hoc*. Classical intertemporal optimization perfect foresight dynamic models stretch credulity especially when applied over a period of time and can explain the behavior of actual economies only with arbitrary adjustments. They may apply to a long-run steady-state, but not to the medium- run, where actual economies are. These problems also constitute the heart of much debate in macroeconomics and growth.

A model is constructed that endogenously generates dynamic price and output paths for the non-agricultural sector of the Indian economy. It is based on the microeconomics of a representative firm that maximizes profits while facing a demand or capacity constraint and optimally makes a mark-up, output, and investment decision. The mark-up decision helps ensure smooth output growth path that are found to correspond to those of the Indian economy in empirical simulations. The firm's price setting, and model dynamic give a theoretical explanation for real price rigidities, persistent excess supply, and periods of high and low growth. Endogenous growth is generated due to amplification of linear shocks. The model builds on ideas contained in the general equilibrium macroeconomics literature (Malinvaud, 1980, 1983) and New Keynesian economics (Mankiw and Romer, 1991) applied to growth dynamics and price setting (Goyal, 1989, 1993). Counter-factual high growth simulations are carried out with the model.

The analysis also helps resolve the closure debate[1]. In a two-sector model with surplus labor, this may be paraphrased as saying that full capacity utilization, the firm on its optimal supply curve, and an independent investment function cannot all hold together. A positive mark-up, excess capacity and the investment function are all obtained from optimizing decisions of the firm over di equilibrium adjustment paths. Dewatripont and Michel (1987) point out that the closure problem arises because of the dynamic nature of investment and savings decision. They suggest that allowing price expectation of financial assets to influence real variables in a temporary equilibrium framework would give the extra variable required to resolve the closure debate. In this paper modeling of disequilibrium adjustment paths gives a theoretically consistent explanation of the mark-up, and provides the extra variable. Money and credit are only implicitly modeled. The satisfactory modeling of these raises vexed issues. In making the simplifying assumption of endogenous credit, we are following diverse theoretical traditions such as real business cycle, structuralist, and imperfect information- based credit market models. The adjustment paths are generated by investment savings dynamics. This is consistent with both the medium-run perspective in this paper and the closure debate.

Policy conclusions obtained from simulations are confirmed when the model is used to determine non-agricultural price and output in the more elaborate, ten-sector applied general equilibrium model (AGEM) developed by Narayana, Parikh and Srinivasan (1991). While the dynamic model is open in a number of ways, the AGEM is closed, has many consistency requirements and balance conditions, more empirical detail, and an endogenous nine-sector agriculture, so that the unchanged outcome represents a further validation of the dynamic model. Results are obtained regarding agriculture, industry interaction, and resource flows to non-agriculture. Policy interventions necessary for sustained high growth with equity are highlighted.

The structure of the paper is as follows. The dynamic model is presented in the next section. The different possible equilibria and dynamic trajectories are enumerated. Section 3 isolates the trajectories that correspond to price and output data for the Indian non-agricultural sector, and finds that parameter values required for historical correspondence generate tests of

[1] Dewatripont and Michel (1987) review the closure debate with special reference to AGE models. Sen originally showed that in an aggregative macroeconomic model it is not possible to have full employment of labor, factor prices determined by marginal productivity, and an independent investment function. In the AGE literature the debate has been about the practical question of which macroclosure rule to adopt, and how to satisfactorily mesh macroeconomic flows in a general equilibrium structure.

alternative price setting hypothesis. In Section 4 results for policy obtained by analyzing high growth simulations with the dynamic model are presented. The additional insights obtained by incorporating the dynamic model are presented. The additional insights obtained by incorporating the dynamic model in the AGEM are briefly explored. Section 5 concludes.

2. The Dynamic Model

A simple theoretical two-sector general equilibrium macromodel is reduced to a two equation nonlinear dynamic system (see appendix). The main assumptions of the model are:

1. There is a representative (or *n* identical) firm(s), two representative consumers, a government, and one asset. Agents recognize that it takes a long time to reach the steady state and maximization is undertaken over medium-run adjustment paths.
2. The output of the non-agricultural sector is the minimum of demand or supply, so that excess capacity is determined endogenously. The modelling of the supply side is simplified by taking the output capital and labour-output ratios as given by their historical series. Some theoretical exercises with the model, introducing substitutability in inputs (see Goyal, 1989, Ch.6) indicate that the results are not affected.
3. A number of links on both the demand and supply side are postulated between agriculture and industry. Certain simplifying assumptions are made at a first stage. (a) Investment goods are produced, and incomes are taxed, only in the non-agricultural sector; and (b) profit earners consume, imports are of, and the government consumes, only non-agricultural products. Together with the erogeneity of agricultural output and price, these allow the model to be reduced to a relation between investment and savings where the only major endogenous link between the two sectors that remains is through agricultural savings. These assumptions, except (a), are relaxed in the AGEM.
4. Nominal wages are given by a derived historical series and the labour market is not modelled endogenously. This is not so restrictive because: (a) the exogenous factor choice and surplus labour assumption; (b) only a fraction of wages form a source of demand for non-agricultural goods; and (c) the long- run mark-up is shown to be relatively constant. The implication is that there is very little feedback from wages to non-agricultural output.
5. Money supply is implicitly, and public sector investment, explicitly modeled through the government budget constraint. The credit market is imperfect. No loans are available for consumption. All wages and a fixed proportion of profit income are

consumed. The real rate of interest is fixed below market clearing levels, and while credit is freely available for 'blue chip' proposals, risky or low productivity investments are rationed. This is modeled most simply by making private sector investment a function of expected profitability and public sector of resource availability.

Dynamic, non-linear price and output paths are simultaneously determined by a reduced form of two differential equations when output, y_m, is less than capacity,$\bar{y}$. The endogenous variables are u, the output-capital ratio, andτ, the mark-up.

$$y_m < \bar{y}: u' = f\big(I(u,\tau) - S(u,\tau)\big) = f(u,\tau) \tag{1}$$

$$\tau' = g(y,\tau) \tag{2}$$

$$y_m = \bar{y}: u = \bar{u} \tag{1'}$$

$$\tau' = f(u,\tau), \tau < \tau_{max} \tag{2'}$$

The trajectories or adjustment paths of the dynamic system in Equations 1 and 2 can be regarded as determined by the intersection of shifting short-run (or one period, see the appendix) aggregate demand and supply curves. Along the paths, there is disequilibrium in two senses: (i) Markets do not clear, that is, there are excess capacity and excess profits (Malinvaud 1980); and (ii) sectoral excess demands are not zero. The growing modern sector is able to pull resources from other sectors.

Output is normalized by capital stock to reflect the medium-run focus. The curves with $u' = 0$ and $\tau' = 0$ in Figure 1 represent the aggregate demand and supply curves facing the representative firm. Their nonlinearity makes multiple equilibria or steady states with excess capacity and positive mark- ups possible.

The specification of' the mark-up τ(see Equations A.13 and A.14) implies that $\tau$is the profit share and τu the rental rate on capital.

Equation 1 models quantity adjustments in normalized output in response to excess demand.

With both investment and savings hyperbolic function of τu and $|f_u| > |f_\tau|$ (sec the appendix), the $u' = 0$ curve is convex to the origin.

We have the following restrictions on aggregate demand:

$$f(0,0) \lesseqgtr, f_\tau \gtreqless 0, f_u \gtreqless 0, |f_u| > |f_\tau|, f_{\tau u} \gtreqless 0, f_{\tau\tau} = 0 f_{uu} = 0 \quad (3)$$

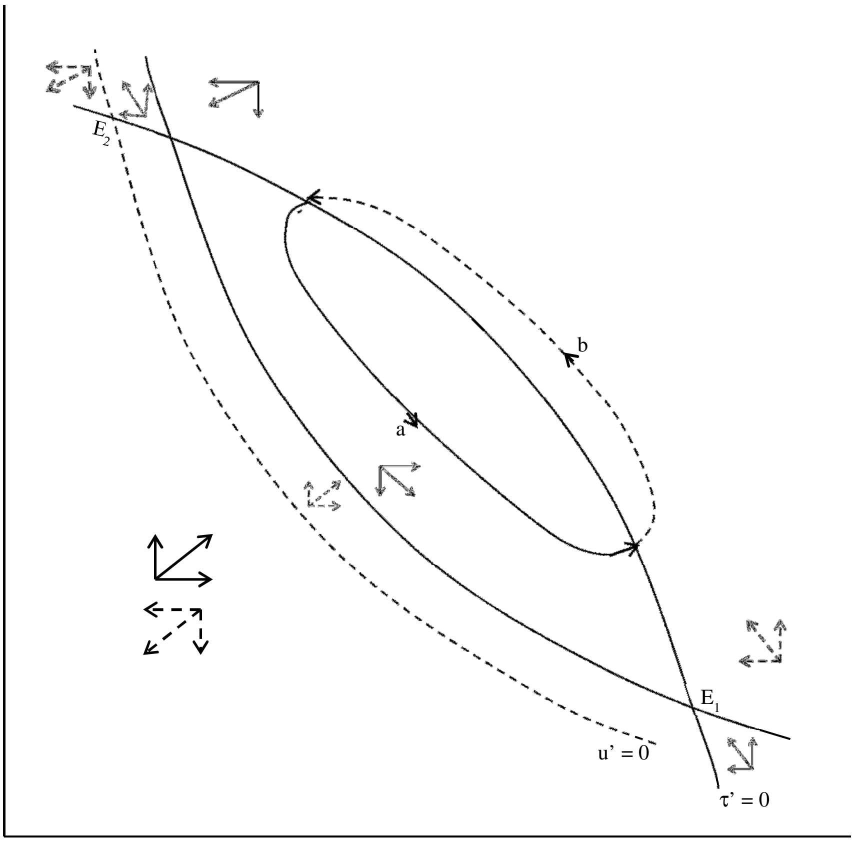


Figure 1: The dynamic flow when mark-up varies inversely with u. Solid lines refer to the case of multiplier stability and dashed lines to the reverse. The curve on which u' = 0 is the aggregate demand, andτ' = 0 gives aggregate supply.

There is nothing in theory to rule out the case of $f_u > 0, f_\tau > 0$ or Keynesian multiplier instability, where inducement to invest exceeds inducement to save, out of non-agricultural income[2]. Even with this possibility, the output response need not be unstable and the firm would maximize expected profits, provided some restrictions are placed on the price response in Equation 2 (Goyal, 1993). These are:

[2] Malinvaud (1983) sees an important link between multiplier instability, tamed by lags, and virtuous growth cycles. In the model developed here, a favourable growth scenario occurs with multiplier instability tamed by price setting behaviour

$$g_u < 0, g_\tau < 0, g_{\tau\tau} < 0 \text{ and } |g_\tau| \text{ is large} \tag{4}$$

A brief rationale for Equation 4 follows.

1. If $g_\tau < 0$ and $|g_\tau|$ is large, violent fluctuations in output are prevented even if $f_u > 0$. Smooth adjustment paths, and a stable equilibrium E_2 (Figure 1) exist. Only small changes in the mark-up occur if $|g_\tau|$ is large.
2. If $g_u < 0$, it is proved in Goyal (1993) that the firm maximizes expected profits over the different possible adjustment paths. In such a case, downward sloping trajectories such as *b* and *a* (Figure I) dominate. The variability of profit is less along such trajectories as *u* and τ move in opposite directions. These more average profits would be preferred by a risk-averse firm, compared to larger profit fluctuations along upward sloping trajectories that dominate when $g_u > 0$. Also with $g_u < 0$, recessionary downward sloping trajectories of falling *u* and τ would be avoided.
3. $g_{\tau\tau} < 0$ ensures nonlinear adjustment to upper and lower bounds on τ.
4. For a monopolistically competitive firm, we have that the mark-up varies inversely with the elasticity of demand. Even a competitive firm in disequilibrium faces a demand elasticity of less than infinity. The mark-up is not ad hoc, but defines a virtual pike (Neary and Roberts, 1980) that makes it optimal for the firm to produce at the demand constrained output level. Higher investment and capital stock, in periods of rising *u*, imply greater variability of output and a higher elasticity of demand. The first-order conditions of short-run profit maximization of the firm then yield $g_u < 0$ or an inverse relationship between *u* and τ.

Figure I shows the aggregate demand, supply, and the dynamic flow when $g_u < 0$. The dashed lines indicate the case when Keynesian multiplier stability does not hold. As the partial derivatives of the demand function change signs, a bifurcation occurs in the dynamic flow and there is a switch from the low (*a*) to the high (*b*) growth trajectory. A growth cycle is made up of *ba* and the trajectories joining them. Equilibrium E_1 and E_2 are saddle-stable, so that *b* and *a* are unique paths (Goyal, 1993).

Why does a bifurcation take place? Rational expectations and other cross-equation restrictions on the underlying structural model lead to changes in the multiplicative parameters in response to exogenous demand or supply shocks. Endogenous difference-stationary growth cycles occur.

It is hypothesized that, for the Indian economy, agricultural supply shocks, a decline in foreign aid, and oil-price shocks from the mid-sixties led to a fall in public investment. Private expected profitability fell. Rational expectations over altered expected adjustment paths led to reduced private investment propensities (Goyal, 1993). The economy switched from trajectory b approaching E_2 to a approaching E_1. In the mid-seventies the large inflow of remittances from non-resident Indians led to a deliberate policy of budget deficits to run down foreign reserves. Public investment increased, with domestic resource requirements met by a large increase in domestic borrowing. That is the coefficient on private savings or τu in the public investment function rose. The amplification effect outlined above worked in the reverse direction and the economy switched once more to b.

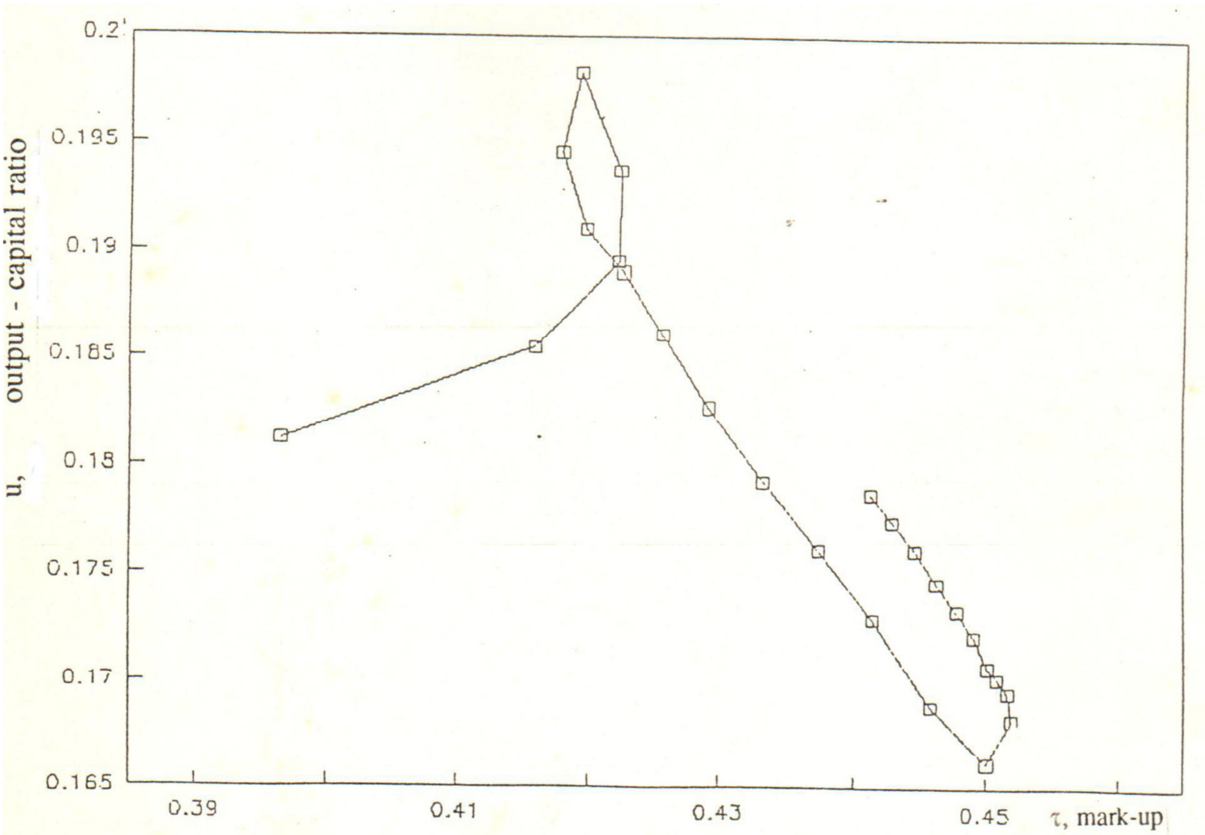
3. Empirical Tests

Since the model is theoretical, highly aggregative and non-linear, it was decided to test it by performing computer simulations using varying parameter value. The objectives were to test (i) if the historical series could be replicated and estimates of likely parameter values obtained; (ii) if the hypothesis of $g_u < 0$ against $g_u > 0$ held; (iii) if $y_m \leq \bar{y}$; and (iv) if the economy switched from b to a and back again.

Since the specification is unusual, (1) is indeed a test of its validity. The simultaneous equation method of calibration (see Appendix) imposes more discipline than many single equation estimates. The method is also broader than other calibration exercises since it involves the test (ii) of competing theoretical hypotheses. The test (iii) is necessary since the endogenous growth amplification effects would occur only if there were excess capacity. When$y_m = \bar{y}$, the dynamics change and the mark-up is the variable that now responds to excess demand (Equation 2') subject to a maximum, τ_{max}. In the Indian economy for the period considered, it was found that$y_m < \bar{y}$. The capacity constrained case arises in some of the high growth counter factual simulations considered in Section 4.

The equations were solved numerically using the classical fourth-order method of Runge-Kutta. Simulations used Indian economic data[3] for the period 1960/61 to 1984/85. The historical time series (H) for u and τ are quite closely reproduced by the simulated series SI. Parameter values consistent with theoretical priors are obtained (see appendix). The trend of the τ(H) series is captured. Short-run fluctuations are explained by lags in price-setting in other simulations. The τ(H) series being derived from inadequate data is not very reliable, especially after 1974/75. A number of alternative data sources are used as a check.

The parameter set A.d (see Appendix 4), with $w = -1$ or $g_u < 0$, generates series S I and forms the basis for counterfactual simulations. The trajectories comprising S I approach E_1 (for the pre-1965/66 period), E_2 (for 1965/66 to 1974/75), and E_1 again post-1974/75. There is a switch from b to a and back as hypothesized. The simulated trajectories in Figure 2 can be compared to b a in Figure I.



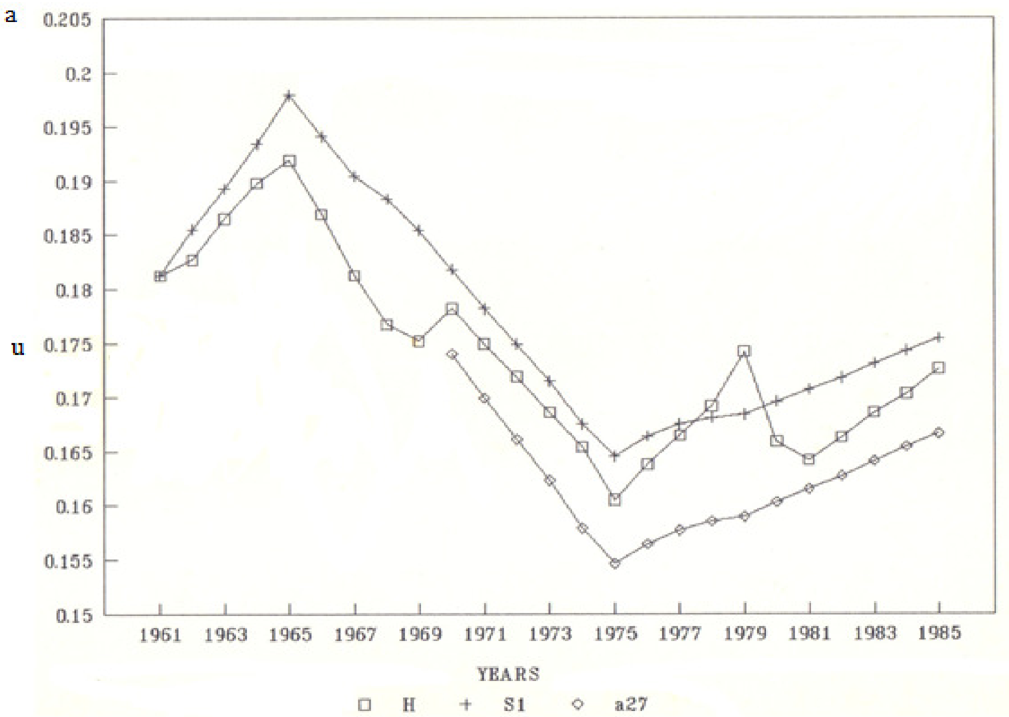
[3] Data sources mainly comprise CSO, RBI, and Government of India publications. The manufacturing sector is the organized and unorganized manufacturing including services. A number of macroeconomic studies for the Indian economy were surveyed to isolate a range of likely parameter estimates. The exogenous e series were obtained as residuals from historical data series.

Figure 2: Trajectories simulated for the Indian economy over the period 1960/61 to 1984/85 correspond to *ab* in Figure 1

Figure 3 (τ) also shows series S2 (generated by (A.d) with $w = 1$ or$g_u > 0$. They cannot explain the perceptible rise in mark-ups that occurred in the late sixties. The simulations reported in Figure 3 (τ) verify that only mark-up behavior with $g_u < 0$ is capable of reproducing the historical T series for the period 1965/66 to 1974/75. The τ(H) series after 1974/75 is not sufficiently reliable to discriminate between the simulations. Even so, the simulations seem unable to falsify the weak hypothesis that when firms face declining demand in the neighborhood of unstable multipliers, they will not decrease mark-ups for fear of unstable price and output decreases.

Irrespective of whether$g_u \gtreqless 0$, the mark-up behavior modelled was essential for stability in the sense of prevention of large fluctuations in output. This is proved in simulations with the full model where fixed prices lead to violent ahistorical short-run fluctuations in output.

The high value of w_2 established implies a very gradual change in mark-up. Lower(higher) values of w_2 that generate a higher(lower) τ give rise to u which is lower(higher) than the historical series and also does not catch the turning points of the τ series accurately.



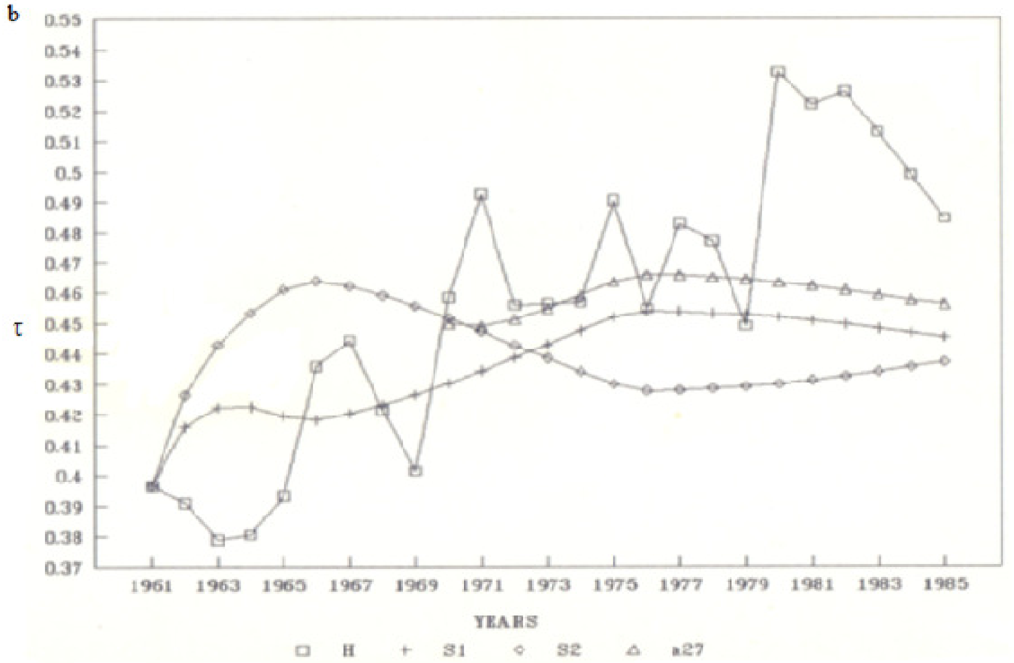


Figure 3: Simulations in (a) the output-capital ratio, u, (b) the mark-up, τ

4. Counterfactual High Growth Simulations

We examine the changes that would lead to higher growth in the model and the structure of these high growth paths, first in the dynamic model and then in the extended AGEM. The latter also allows us to look at aspects of agriculture-industry interactions, income distributional changes, and inter-sectoral resource flows. Finally we draw together the implications for policy.

4A. The structure of growth

Any simulation involving an increase in the inverse multiplierΩ would imply a switch to a higher growth path. The change in Ω could be brought about by a rise in any of the investment propensities or a fall in the saving propensity. Simulation *S* 11 in Table 1, reports the percentage increase in some macroeconomic variables, resulting from a fall in *f* to 0.35 after 1964/65 (~ 55 per cent rise in Ω). This simulation reconstructs the possible growth path if there had been no dip in foreign inflows and public investment in the mid-sixties. Among the conclusions from this and other simulations (see Goyal, 1989) are the following:

1. The percentage change in τ is less than one-third the percentage change in y_m.
2. The influence of y_m on I_p is greater than on I_G, as a corollary I_p responds more strongly to a given change in I_G through the effect of the latter on y_m. There is complementarity between I_p and I_G in the long run, while high inflation and a resource squeeze can cause reverse crowding out of public sector investment.
3. Change in Ω is much stronger than that of equivalent changes in e. To generate an equivalent growth path would require a 6 to 16 times higher initial investment in the latter case. A 'big push' in investment is not essential. It is adequate for high growth that investment should rise as a reasonably high percentage of output.
4. The relatively small changes in τ indicate that cost-push factors are the major cause of inflation.
5. Reversible shocks have persistent long run effects or difference stationary growth cycles occur.

The dynamic model was used to determine non-agricultural output and prices in the AGEM developed by Narayana et.al (1991) for agricultural policy analysis. In the AGEM, non-agricultural output and prices are given by historical data for the period 1969/70 to 1984/85, over which it is calibrated. After that non-agricultural output is determined by capacity which is a function of past investment while prices remain fixed. The dynamic model allows output to be the minimum of demand or capacity, and also endogenizes non-agricultural prices. The latter are obtained by applying the mark-up to historically given labor-output ratios and money wages.

Agricultural price and output is now endogenized through empirically estimated demand and supply curves. Supply in agriculture is fixed in one period and changes in the next. Income distribution is also endogenized, so that relative prices change as both the level and the distribution of income changes in the high growth simulations.

Since a demand system is not estimated for non-agricultural output, relative price effects on non-agricultural consumption demand are not captured. The real value of endogenous household saving and residual government dissaving depends on non-agricultural price. Effects of agricultural output and terms of trade on investment and saving are still kept in the exogenous part, *e*. As they enter with opposite signs they cancel out. The long-run agricultural supply response is higher than the short-run, as the share of investment in agriculture responds to changes in terms of trade. The price elasticity is only 0.25. The share is largely determined by a time trend that captures the historical share of agriculture in investment that has been around 18-20 percent in the eighties.

A key to the major simulations presented in Table 1 follows: S 11- f reduced to 0.35 from 1964/65, *a*17 - i_1 increased 5 percent from 1974/75, *a*27 - base run with (A.d), a28 - $f = 0.35$ with base *a*27, and *a*l9 -f = 0.35, capital-output ratio, $k = 5/(1.01)^t$. *S* prefixes simulations with only the dynamic model, *a*, those with the full model. All simulations are based on the parameter set (A.d), with the changes in each indicated below. The initial year is 1960/61 for simulations with the dynamic model and 1969170 for the extended model.

Figures 3 and 4 report the results of one simulation, *a*27, with 1969-70 as the initial period. Despite the different initial period, which could make a difference as the model is nonlinear, the resulting series follow the trend of both S1 and the historical series. Moreover, simulation *a*28 with $f = 0.35$ from 1969-70, gives results comparable to S11 (in Table 1). Other simulations (not reported for reasons of space) reinforce these results. Simulation results are firmer if they hold for a range of parameter values and doubly so if they hold in a different model.

Table 1: Percentage change over base run

Experiment	Percentage change over base run in year	y_m	u	τ	I_p	I_g	I_{nom}	$s(\tau y_m P_m)$	P_m	P_a	P_a/P_m	$TSAVE_{(nom)}$	y_a	$GCSV_{(nom)}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
S 11	1970-71	8.7	7.2	-2.7	3.0	12.1	6.6*	2.9*	-2.1	-	-	-	-	-
	1984-85	32.1	20.2	-8.5	16.2	24.5	20.2*	12.4*	-6.4	-	-	-	-	-
a 17	1984-85	8.3	7.2	-2.8	60	1.4	1.4	2.0*	-2.3	4.9	5.9	9.9	-	-32.3
a 28	1984-85	37.0	20.0	-8.7	17.9	25.6	13.1	13.0	-6.9	37.8	49.3	60.9	1.1	-193.3
	1998-99	43.6	18.3	16.2	54.9	68.0	83.1	79.4	14.1	-3.9	-16.7	49.3	3.1	0.0
a 19	1984-85	42.6	34.8	-14.4	11.4	20.0	3.0	8.9*	-10.8	36.8	37.3	58.5	-9.4	-210.9
	1991-92	67.8	52.0	-26.4	14.5	25.8	-1.4	11.8*	-17.5	47.5	47.5	71.1	-8.1	-184.6
	1994-95	71.1	52.2	-26.4	18.9	31.1	2.8	15.7*	-16.1	120.0	121.0	74.5	-15.8	-169.2

Notes: nom denotes variables in current prices; others are in 1970/71 prices. *Denotes variables in 1970/71 prices, for S11, a28, a19, f = 0.35, in a17 i_1 increased by 5%

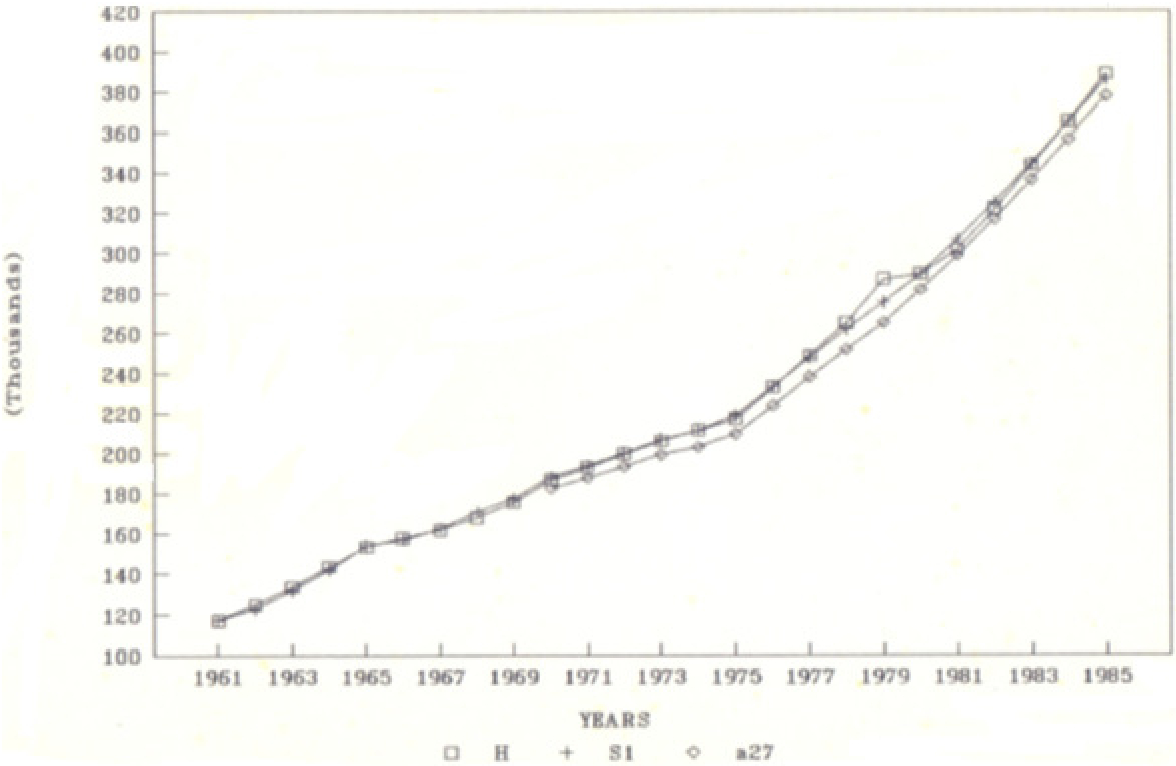


Figure 4: Simulations in output, y_m

4B. Agriculture and resource flows

The structure of the AGEM allows a number of new issues to be considered: (1) the effect of relative prices on demand and growth; (2) the short- and long-run agricultural supply response; (3) the interaction between changes in income distribution and growth; and (4) the investment and savings flows between agriculture and non-agriculture.

In Table 1 column 11, agricultural prices increase with non-agricultural output and respond steeply to a large rise in the latter, but the supply response (column 14) is low. It is higher in the long run, but can even be negative for a steep rise in agricultural prices. In *a*28, full capacity output, (with a capital-output ratio of 5) is reached in 1983-84 after which non-agricultural output grows more slowly. Agricultural terms of trade, after rising steeply, fall below the base run by 1990-91. Agricultural output, which is often below the base run is only 3 percent higher by 1998-99 as a result of increased investment. In a19, again with $f = 0.35$, allowance is made for rising productivity with the capital-output ratio falling to reach 3.8 by 1992/93, when the capacity constraint is binding. Even so, demand once more falls below capacity by 1994/95, when a stock-out is reached.

In a 19, the rates of growth of output (columns 3 and 4), are much higher than in a 17. In the former, supply-side productivity growth, due to new technology or increasing returns to scale allows growth in $\bar{u}$ Full capacity is not reached until 1992/93, so that accelerated demand led growth is feasible until then. Demand cycles arc embedded in supply cycles. The higher productivity of capital and falling mark-ups mean that the rise in investment is lower in a 19, compared to a 28 [columns (6) and (7)]. At the same time, in the former there is a steep rise in the agricultural terms of trade, but a fall in agricultural output. Substitution in consumption, and short- and long-term supply response to relative price changes is inadequate to adjust agricultural demand to supply, given the slow growth in investment. Narayana et. al. (1991) show that raising investment in agriculture and targeting it towards improving the irrigation potential leads to the largest increase in agricultural output.

In the dual economy literature it is established that agriculture can serve as a source of demand for industry if the level of income in agriculture is high and evenly distributed and the price elasticity of food demand is not too low. Neither of these conditions holds for India. In the absence of a rise in agricultural supply, the wage-goods constraint can squeeze non-agricultural demand and profits.

Most dual economy models neglect investment in agriculture. As the majority of investment goods are produced in non-agriculture, a rise in agricultural investment is a source of demand for industry and at the same time, eases the wage goods constraint. A number of studies show that private and public investment in agriculture are complimentary. In India the share of agriculture in both has been declining since the late seventies. That the very large rise in agricultural prices is unable to choke off demand is indirect evidence of the low price elasticity of agricultural demand in India. Increase in public expenditure, apart from investment, cannot be very effective in inducing a rise in demand for industry given the leakage of expenditure to items of food.

The dynamic model showed a gap between investment and savings in each year, which was close to the historical gap and was probably caused by data and deflation problems (Goyal, 1989). The AGEM imposes balance in physical and financial flows for each of 10 rural, urban income groups, ten commodity sectors, the government, and the aggregate investment savings equality. Government is the residual saver and tax rates adjust to maintain balance. It is notable that none of the balance conditions arc violated in the higher growth dynamic simulations unless there is extreme disproportion between the sectoral rates of growth.

It is also notable that nominal total household savings (TSAVE) exceeds investment in most periods so that nominal government savings (GCSV) arc negative. The latter implies that savings are effectively determined by investment. It is even more interesting that in the higher growth scenarios, TSAVE grows faster than investment so that GCSV becomes more negative (see a19, Table 1). In a28 GCSV finally approaches its base run values as growth slows with the capacity constraint holding. The increase in TSAVE exceeds that in savings out of profit income, *S*. This means that the dynamic growing non-agricultural sector can invest in excess of its savings and attract savings from other sectors. Growth can finance itself.

Are the estimates of TSAVE realistic? Narayana et al. (1991) estimate a jointly log-normal distribution of consumption and income that reconciles NCAER (1980) data on cross-sectional income distribution for 1975/76 and C.S.O. time series. This is used to determine the proportion of population, consumption, and savings in different income groups separately for rural, urban and rural non-agricultural population. Table 2 shows how the population and per capita saving vary in different simulations. An important source of the rise in TSAVE is the increase in population in the upper income groups with growth. This aspect is not adequately captured in the normal aggregative macroeconomic savings function. If the parameters of the distribution function change so that the lower income groups benefit more from growth, through increased employment generation the increase in TSAVE would be lower. If there is a larger shift of population to the urban sector, TSAVE would increase. The large numbers that remain in the lower income groups of the rural population, even with high growth indicates that high non-agricultural growth is not sufficient to remove rural poverty. Special measures are required for the agricultural sector. The rise in agricultural prices has an adverse effect on the lower income groups, and in *a*27 the gini coefficient is first higher and then lower than in the base run.

4C. Macroclosure and policy conclusions

Macroclosure issues in this paper can be defined in two different ways: (i) the investment savings balance and its interaction with government finances; and (ii) the rigidity of mark-ups and large quantity variations derived from optimization decisions over disequilibrium adjustment paths. The effect of disequilibrium on the endogenous variables is simply captured without explicitly modeling money and credit markets.

Table 2: Population (in m) and Per Capita Savings (S/c) (in current prices), by Income Groups

		Income Classes				
Experiment	**Year**	**≤ Rs. 216**	**> Rs. 216 ≤ Rs. 336**	**> Rs. 336 ≤ Rs. 516**	**> Rs. 516 ≤ Rs. 900**	**> Rs. 900**
Rural	1984-85					
a27	Population	200.88	103.04	102.95	100.27	49.79
	S/c	-16.84	120.60	402.75	1180.86	4177.70
	1998-99					
	Population	199.37	108.88	124.89	156.98	118.03
	S/c	—	—	—	—	3834.30
Urban	1984-85					
a27	Population	8.45	23.34	44.24	61.36	42.72
	S/c	-16.46	14.06	225.27	839.65	3679.24
	1998-99					
	Population	3.86	18.02	54.10	117.44	124.13
	S/c	—	—	—	—	3758.40
Rural	1984-85					
a28	Population	200.22	100.81	97.16	97.51	61.23
	S/c	-16.84	121.05	410.30	1246.60	5728.90
	1998-99					
	Population	200.10	108.42	118.20	132.31	149.11
	S/c	-30.30	44.20	224.32	889.10	4734.80
Urban	1984-85					
a28	Population	3.74	14.56	35.71	64.13	61.98
	S/c	-61.99	13.02	229.23	874.91	4244.30
	1998-99					
	Population	1.31	8.33	33.65	101.94	172.32
	S/c	-68.51	-18.98	149.40	725.43	4667.20

On the high growth paths, savings exceeded investment and the public sector was a net dissaver. In the Indian economy the latter has indeed been the case. With borrowing supporting even current expenditure and low returns from public sector investment, public debt was reaching unsustainable levels. The stabilization imposed in the nineties seeks to bring down the fiscal deficit. Unfortunately the latter is being attempted by cut down of public investment and privatization, without controlling the revenue deficit. The privatization attempts have been failures, as they have taken place in a period of collapsing stock markets, low growth, and investment. If high public sector investment could, according to the counterfactuals analyzed in this paper, maintain high growth, resources to finance it could be allocated to the public sector by privatization. While the stock of public sector capital would be unchanged, its share could fall as private investment also rose. This happened in Taiwan. The sale of shares in select enterprises, together with other market structure reform would help to increase the efficiency of public enterprises. There is some evidence that in periods of low growth, resources flow into speculative activities (Goyal, 1992). With greater openness, foreign inflows would also be more easily attracted by high growth. In the current agriculture-industry model, flows between the two must balance. We have seen how investment in agriculture lead by public sector investment would be balanced by agricultural savings flowing into the non-agricultural sector on a high growth path. Simulation a19 suggests that the current policy initiative of giving farmers higher prices may not succeed if not supported by a rise in investment.

Since the non-agricultural sector is not disaggregated, the mark- up decision of the representative firm reflects macroeconomic forces that impinge on its expected demand. Given the structure of the model, the latter, in turn, is directly determined by investment and savings dynamics. Focusing on the latter makes possible a medium-run perspective, rather than that of short-run macro-monetary fluctuations. There is some empirical evidence about the better performance or macro- relative to micro-variables in firms' decisions[4]. The above analysis may be valid even leaving the representative firm framework, with a more disaggregated non-agricultural sector. The mark-up in each sector would be determined by its market structure, and dynamic macroeconomic considerations.

In AGE models, it becomes difficult to explain or calibrate the model to observed country high-growth experiences in the Walrasian framework. Recent work has tended to impose arbitrary supply-side increasing returns to scale or technology shocks. The model in this paper uses endogenous demand-side intensifications of growth, caused by either demand or supply shocks.

[4] In a study by Grunfeld and Griliches (1960), investment functions for firms using aggregative variables performed better than those using disaggregative firm level variables. There is also work on the relationship between macrofluctuations and the mark-up in the Industrial Organization and Post-Keynesian literature.

In the dynamic model, the mark-up is endogenized and found to be relatively rigid and countercyclical. The price level is normalized at one for the base period. Endogenizing money wages and linking them to agricultural prices could explain the price level.

The combined insights of the dynamic and AGE models lead to the following policy conclusions:

1. It is feasible to shift to a higher growth path provided less costly means are devised to improve the allocation of savings to the public sector, and sustain investment increases. As both the quantity and allocation of savings is responsive to high growth and profitability, sale of public sector enterprises would be feasible on a high growth path and could be used to maintain high public investment.
2. Allocation of investment for irrigation and employment in agriculture should be increased to control rise in prices and their adverse income distributional, growth, and political consequences.
3. A new approach to policy in line with the mechanism design literature is desirable. Policy should seek to identify feasible variation in parameters that, by changingΩ, would change the dynamics of the system. Growth could intensify and/or a favorable bifurcation could occur in the growth path.

5. Conclusion

In this paper by using a simple technique to model disequilibrium without modeling money markets explicitly we (i) suggest a possible solution to the closure debate, (ii) obtain relatively rigid counter cyclical mark-ups in a theoretically consistent way, (iii) show that, given the latter, investment savings dynamics can explain endogenous growth amplifications, and (iv) use the model to explain growth paths for the non-agricultural sector of the Indian economy. Counterfactual simulations (i) with the dynamic model (ii), putting the latter in an agricultural policy AGEM show:

1. Public sector investment 'crowds in' private sector investment, and is itself crowded out in periods of resource constraint. Both are complementary in agriculture.
2. In Indian agriculture, at least historically, supply response to the terms of trade has been low. Supply responds to increased allocation and targeting of investment.

3. On counterfactual high-growth paths without increase in investment in agriculture there is no alleviation of rural poverty and a steep rise in agricultural terms of trade with adverse effects on growth.
4. On the high-growth simulations household savings exceed investment.
5. Savings required for successful privatization would flow to the public sector if the proceeds were used to maintain high public-sector investment with a large allocation to agriculture. The latter would be a prerequisite for high growth until structural adjustment successfully changes the dynamics of the system.

APPENDIX

1. The One Period Model

The endogenous price and quantity variables in a given period are determined by Equations A.1 to A.14 in Table A.1. The symbols are defined in Sections 1A-1C. Equation A.1 gives the short-run non-agricultural mark-up n as the excess of non-agricultural price over direct, indirect labor input coefficient, and profits are $n\ y_m$. The equation shows that price in a given period may be fixed as a function of long-run mark-upτ. These equations are the first-order conditions of profit maximization by the representative firm. The long-run mark-up τ will differ from n only if price is a lagged function of costs, was taken to be the case in some simulations.

Equation A.2 builds up the capital stock in non-agriculture as sum of last period capital stock and investment in non-agriculture, subtracting the part of investment going to agriculture. Capacity output is obtained from the capital stock, given an output-capital ratio.

The rest of the equations determine output and its components. In A4, aggregate demand for non-agricultural output is built up as a of all the standard categories minus net imports of industrial products, F_m. Investment is broken up into that originating in the private and that in the public sector. Consumption is broken up into consumption of non-agricultural output out of agricultural income, wage income foreign inflows, and profit income. It is assumed that workers consume all their income and have a fixed minimum consumption of agricultural commodities.

Non-agricultural output is the minimum of demand or capacity (A.5) and along with agricultural output (exogenous) adds up to total output. Public sector investment (A.7) is derived from the government budget constraint. Given restrictions on inflationary deficit finance and dependence on institutional and other market borrowing, it is an increasing function of the different categories of savings, and a decreasing function of rise in agricultural prices. Private sector investment (A.8) is obtained from the representative firm's maximization of expected net cash flow subject to a probability of making sales. It is an increasing function of profits and a decreasing function of excess capacity. This is equivalent to the 'q' theory of investment with excess capacity adding an opportunity cost element to adjustment costs[5]. An implication of this specification is that to$|f_u| > |f_t|$. Savings (A.10-A.12) is broken up into domestic and foreign savings, and savings out of non-agricultural profit income, and agricultural income. Consumption/savings behaviour is derived from consumer utility maximization under employment and liquidity constraints. Quantities are measured in money (Rupees) with P_m as the numeraire, so that all variables expect $W$are in units of non-agricultural output.

Table A.1 The Equations of the Model

$$n = 1 - \frac{W}{P_m}a_1 - \frac{P_a}{P_m}a_a - \frac{P_{1M}}{P_m}a_{1M} - \frac{P_G}{P_m}a_G - \frac{r}{P_m}a_A \tag{A.1}$$

$$K_t = K_{t-1} + I_{t-1} - I_{agr(t-1)} \tag{A.2}$$

$$\bar{y} = vK \tag{A.3}$$

$$d_m = I_p + I_G + C_m Y_a \frac{P_a}{P_m} + \left((1 - c_a)a\frac{W}{P_m}y_m - c\frac{-P_a}{P_m} \right) \tag{A.4}$$

$$+c_2F_2 + (1 - s)nY_m + G - F_m$$

$$Y_m = min.(d_m, \bar{y}) \tag{A.5}$$

$$Y = Y_m + \frac{P_a}{P_m}Y_a \tag{A.6}$$

5 Wilcoxen (1993) has recently argued that it is important to understand the nature of adjustment costs. The latter determine the long-run supply elasticity, which is one of the most vexed questions in satisfactory modeling of dynamic AGEMs

$$I_G = I_G^A + g_1(1-f)(sny_m + \frac{P_a}{P_m} s_a Y_a) \tag{A.7}$$

$$+g_2 P'_a + F_1 \qquad g_1 > 0, g_2 < 0$$

$$I_p = I_p^A + j(min.(d_m, \bar{y}) - \bar{y}) + i_1 n y_m + i_2 F_2 \qquad j, i_1, i_2 > 0 \tag{A.8}$$

$$I = I_G + I_p \tag{A.9}$$

$$S_D = sny_m + s_a y_a \frac{P_a}{P_m} + S_G \tag{A.10}$$

$$S_F = F_1 + s_2 F_2 \tag{A.11}$$

$$S = S_D + S_F \tag{A.12}$$

$$\pi = y_m - \frac{W}{P_m} a y_m = n y_m \tag{A.13}$$

$$P_m = aW/(1-\tau) \tag{A.14}$$

$$u' = e + \big((i_1 + g_1 s(1-f) - s)\tau + j\big)u \tag{A.15}$$

$$\tau' = w_1 u - w_2 \tau^2 + w_3 \qquad w_1 \gtrless 0, w_2 > 0, w_3 \geq 0 \tag{A.16}$$

$$e = e_G + e_p - e_s \tag{A.17}$$

$$e_G = (I_G^A + g_2 P'_a + F_1 + g_1 s_a e_\tau (1-\tau) y_a)/K' \tag{A.18}$$

$$e_p = \big(I_p^A + i_2 F_2 - j\bar{y}\big)/K \tag{A.19}$$

$$e_s = S_G + S_F + s_a e_\tau (1-\tau) y_a)/K \tag{A.20}$$

$$e_\tau = P_a/(Wa_1 + P_a a_a + P_{1M} a_{1M} + P_G a_G + r a_k) \tag{A.21}$$

1A. Endogenous variables (equal to number of equations)

n = fixed price mark-up for non-agriculture

K = capital stock in non-agriculture

$\bar{y}$ = capacity output of non-agriculture

d_m = demand for non-agriculture

y_m = output of non-agriculture

y = total output

I_G = public sector investment

I_p = investment by the private sector

I = total investment

S_D = domestic savings

S_F = savings out of foreign inflows

S = total savings

π = total profits in non-agriculture

P_m = price level of the non-agriculture sector

$u = y_m/K, \bar{u} = \bar{y}/K$

τ = mark-up in non-agriculture

e_G, e_p, e_s = constituents of I_G, I_p, S respectively taken as exogenous in the dynamic model

e = the exogenous part of aggregate I minus S

e_τ = ratio of P_a to all per unit input costs

1B. Exogenous Variables

W = money wage rate

P_a = price level of the agricultural sector

P_{IM} = price level of intermediate imports

P_G = price of intermediate inputs produced in the public sector

r = nominal rate of interest

v = full-capacity output-capital ratio in non-agriculture

I_{agr} = investment in agriculture

y_e = output of the agricultural sector

G = government consumption expenditure

T = government taxes

F = foreign inflows, $F = F_1 + F_2$, in units of non-agricultural product

F_m = imports in excess of non-agricultural exports

F_1 = foreign inflows to the public sector

F_2 = foreign inflows to the private sector

$P^*_a = dP_a/dt$ a superscript dash always indicates a time derivative

S_G = public sector savings

1C. Parameters

a_1 = direct labor requirements per unit of y_m

a_a = agricultural raw materials per unit of y_m

a_{IM} = intermediate imports per unit of y_m

a_K = intermediate inputs (produced in the public sector) per unit of y_m

a_K = working capital per unit of y_m

c_m = propensity to consume non-agricultural goods out of agriculture income

c_a = propensity to consume agricultural output out of wage income in non-agriculture

a = direct and indirect labor requirements per unit of y_m

$\bar{c}$ = fixed consumption of agricultural products by workers in non-agriculture

c_2 = propensity to consume out of F_2

s = propensity to save out of profit income in non-agriculture

g_1 = public sector propensity to invest out of private sector savings

g_2 = the effect on I of the rate of growth of agricultural prices

s_a = propensity to save out of agricultural incomes

f = a dummy variable effecting the public sector propensity to invest out of savings in the manufacturing sector

j = a parameter capturing the effect of aggregate demand in relation to capacity on I_p

i_1 = private sector propensity to invest out of profit income

i_2 = private sector propensity to invest out of F_2

w_1, w_2, w_3 = parameters of the τ' function

2. The Dynamic Model

Equation A.IS models the adjustment of non-agricultural output equate savings to investment, all normalized by capital stock. The exogenous parts of investment and savings, which are functions of agricultural income and price, intermediate input prices, and foreign inflow, are gathered together in the e terms (A.17-A.21), and u' becomes a nonlinear function of u and τ. As a simplifying assumption, terms of trade effects on agricultural savings are treated as exogenous. The dynamics are dominated by the term $\Omega = (i_1 + g_1 s(1 - f) - s)\tau + j$, which is the negative of the inverse of the Keynesian short-run multiplier.

3. Calibration

Historical time series for the endogenous variables, the exogenous series of the e's, W, a, I_{agr} and initial values of u τ, K were derived from C.S.O, R.B.I., B.S.I.E. and other sources of data, apart from the work of various scholars. Simulations of the model were run and the values of the investment, savings and τ' equation parameters that reproduced the historical series were isolated. The *e* series were calculated by subtracting the endogenous components of investment and savings from the respective historical series. The calibrated model was then used as a base for counterfactual simulations. The same exogenous series were used in simulations with the AGEM, but the initial period was 1969/70.

4. The Calibrated Parameter Set

Inverse multiplier (Ω) values that generate close approximations to the historical data series are pre-1965/66 = .0194, 1965/66 to 1974/75= -0.0235, post-1974/75 = 0.00546, if $\tau = .4$. Parameter values commensurate with these values of omega and the historical series on saving and investment are:

1. For 1960/61 to 1974/75:, $i_1 = 0.258$, $j = 0.002$, $s = 0.429$, $g_1 = 0.5$, $w_2 = 0.9$, with $f = 0$ for 1960/61 to 1964/65 and $f = 0.5$ thereafter:
2. For 1975/76 to 1984/85:

   $i_1 = 0.32$, $j = 0.002$, $s = 0.479$, $g_1 = 0.7$, $w = 0.9$, with $f = 0.5$ throughout. (A.d)

   Sensitivity analysis confirmed these values

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